FT-NIR Chemical Imaging of a Zirconium Single Crystal with 1 Micron Spatial Resolution

I. C. Baianu (NPRE & FSHN, University of Illinois at Urbana-Champaign)

Abstract
The first 1 micron resolution chemical images of a Zirconium single crystal were obtained by FT-NIR Microspectroscopy with 0.1cm-1 spectral resolution. The FT-NIR spectra were obtained with a PerkinElmer SpectrumONE NTS spectrometer, and the FT-NIR chemical images were obtained with a PerkinElmer Autoimage model FT-NIR microscope equipped with a very high sensitivity In /GaAs detector capable of precise measurements at ~10 ng with high spectral resolution when coupled to a SpectrumONE NTS FT-NIR spectrometer through the side-port.

1. Introduction

- Chemical and hyperspectral imaging have a wide range of actual and potential applications in both fundamental science and industry. Chemical, Biotechnology, Food and pharmaceutical industries, as well as applications in medical diagnosis, are examples of the potential of such novel techniques.

- The high sensitivity and resolution obtainable with state-of-the-technology FT-NIR Microspectrometers make also such instruments a very attractive choice for a wide range of chemical and chemical engineering applications, as well as material science.

2. FT-IR and FT-NIR Microspectrometers

A microspectrometer is defined as a combination of a spectrometer and a microscope that has both spectroscopic and imaging capabilities. Such an instrument is capable, for example, of obtaining visible images of a sample using a CCD camera, and chemical images with an NIR detector. Chemical images are then employed for sophisticated quantitative analyses. The results reported in this chapter for soybean seeds and embryos were obtained with FT- IR and -NIR spectrometers made by the PerkinElmer Co. (Shelton, CT, USA). The FT-NIR (NTS model) spectrometer was equipped with an integrating sphere accessory for diffuse reflectance. The FT-NIR or -IR spectrometers were, respectively, attached to microscopes for the NIR region (NIR Autoimage model) or IR region (model Spotlight 300), as illustrated, respectively, in Figures 1A and 1B. Each spectrometer has an internal desiccant compartment to remove the water vapor and the carbon dioxide from air that may interfere with the spectrum of a sample. Apart from the improved resolution and acquisition time, these instrument models, offer increased sensitivity and also allow the transfer of spectra to different instruments of similar design. The two microspectrometers are each equipped with two cassegrain imaging objectives and a third cassegrain before the NIR detector in order to improve focus and sensitivity.

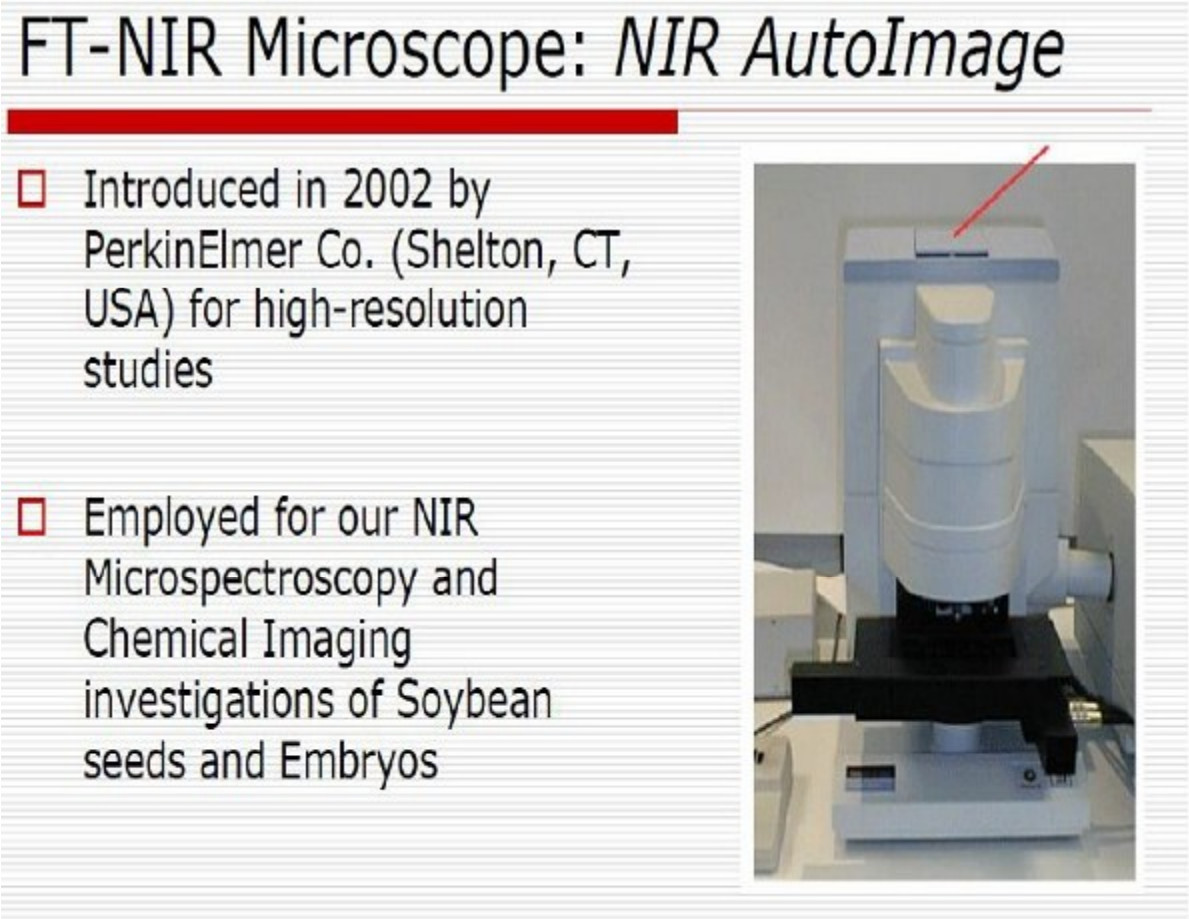

Figure 1A. *FT-NIR Microspectrometer (AutoImage FT-N IR model made in 2005 by PerkinElmer Co.).*

Figure 1B. *FT-IR Microspectrometer (model Spotlight 300) introduced by PerkinElmer Co in 2002.*

3. Image Spatial Resolution Tests

The next Figures 2 and 3 present image resolution tests in the reflection mode obtained with the Autoimage FT-NIR Microspectrometer shown in Figure 1B.

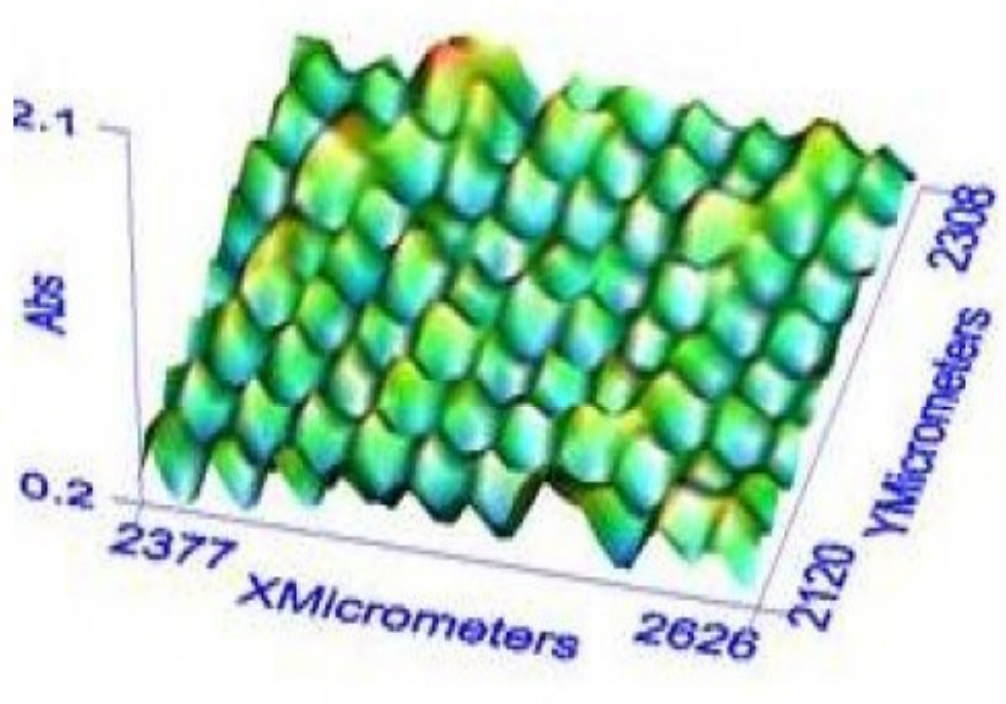

Figure 2. *FT-NIR Microimaging in the Reflection mode of 25-Micron EM copper-grid Microarrays. (Reflection data was converted to arbitrary 'absorption' units).*

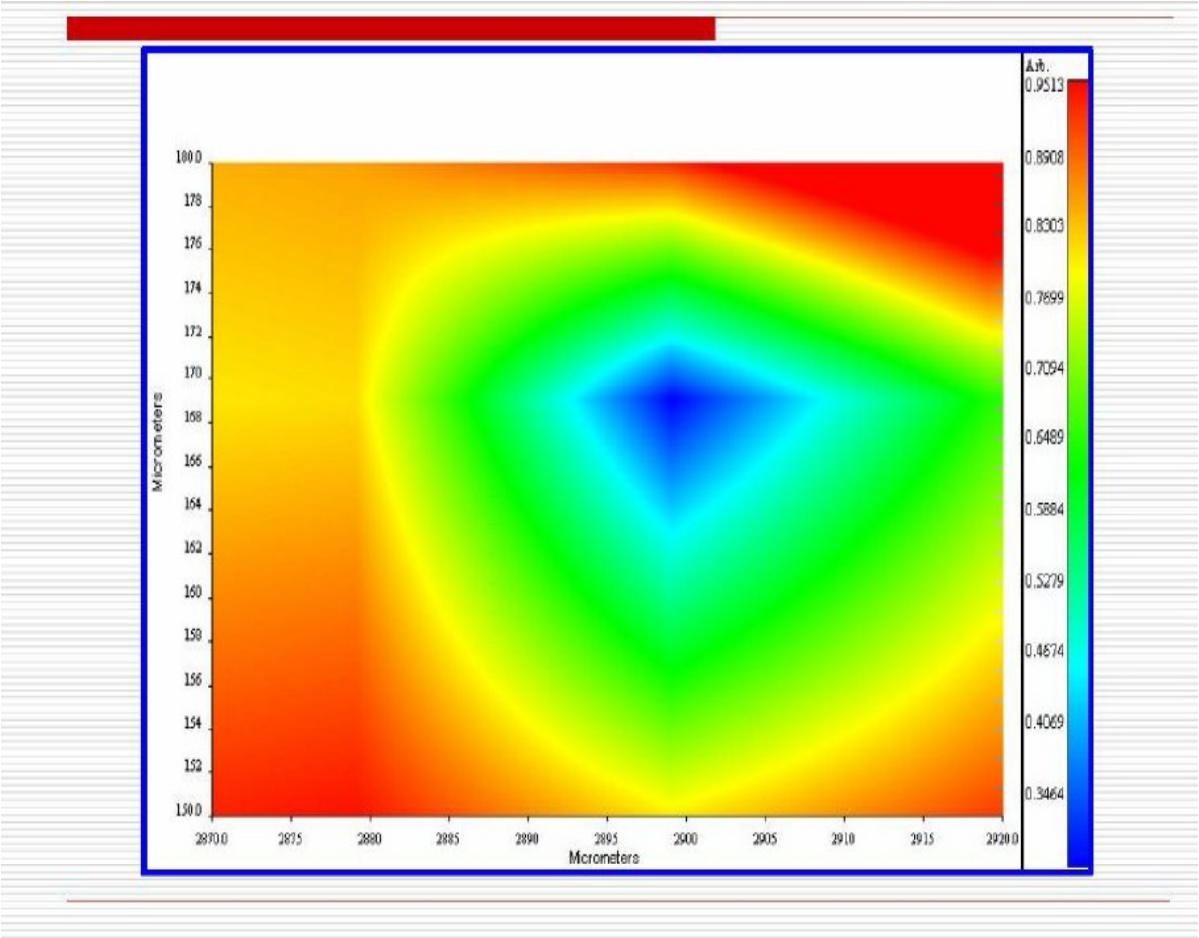

Figure 3A. *FT-NIR Image of a Top Zone in a Cubic Zirconia, 1cm3 Single Crystal at 1 micron spatial resolution; (a plot of the NIR band ratio: 7211.2 , 5253.1cm-1).*

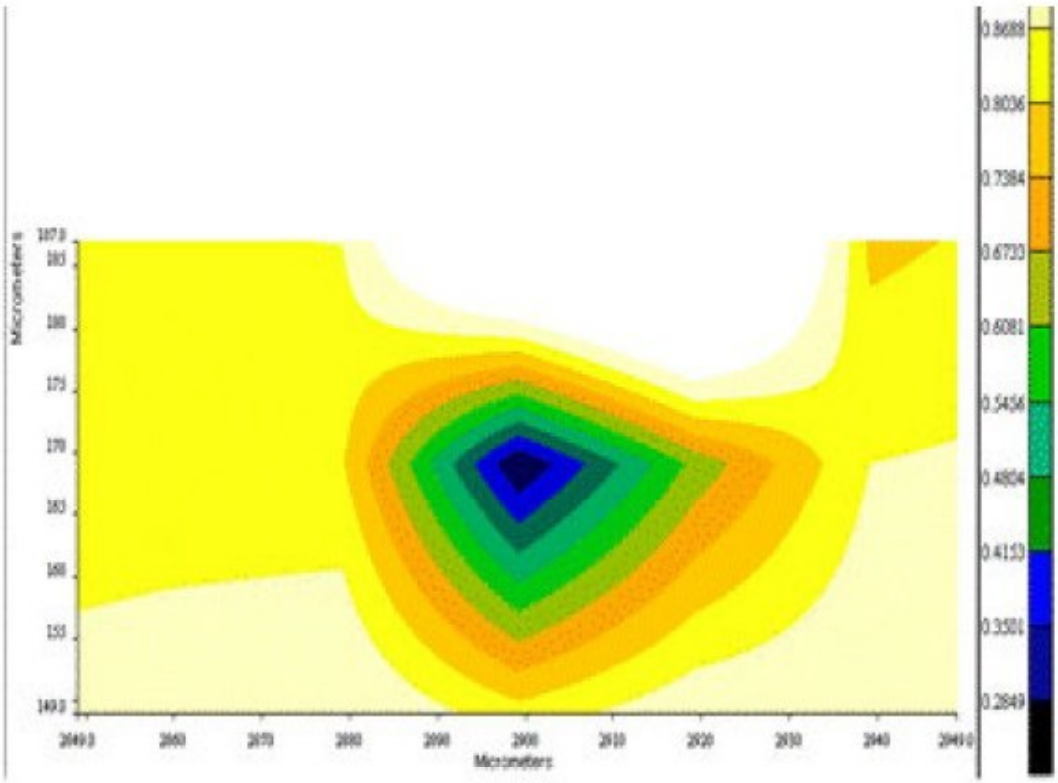

Figure 3B*. FT-NIR Reflection Mode Image of a 1 cm3, Cubic Zirconium Single Crystal at a spatial resolution of 1 micron (As an example, the plot is presented as the NIR band ratio: 7253 to 5485 cm-1, with a large depth of focus).*

4. Conclusions

The results presented in Figures 2 and 3 illustrate the outstanding performance of the Autoimage FT-NIR microspectrometer, reaching 1 micron resolution on a large, 1cm, single crystal of cubic zirconium.
These are the first FT-NIR chemical images at 1 micron spatial resolution for a large single crystal of cubic zirconium. The spectral NIR resolution obtainable in such FT-microspectroscopy imaging can be as high as 0.1 cm^{-1} or better. Signal-to-noise and micro-spectrometer stability are also excellent (>100:1 for single scans).

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